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(54) Pressure sensitive adhesive for use in semiconductor wafer processing

(57) A pressure sensitive adhesive composition comprises an acrylic (co)polymer (A), an energy beam polymerizable urethane acrylate oligomer (B) and an energy beam polymerizable compound having one acryloyl group or methacryloyl group in each molecule thereof (C). This composition is preferred to further contain a plasticizer (D), a crosslinking agent (E) and/or a photopolymerization initiator (F) according to necessity. The pressure sensitive adhesive composition has satisfactory pressure sensitive adherence and initial adhesion before the irradiation with energy beam and the adhesive strength thereof is sharply reduced with maintaining the elasticity after the irradiation with energy beam. The pressure sensitive adhesive composition provides a pressure sensitive adhesive sheet, especially, a semiconductor wafer processing pressure sensitive adhesive sheet or a surface protective pressure sensitive adhesive sheet.

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FIG. 1.

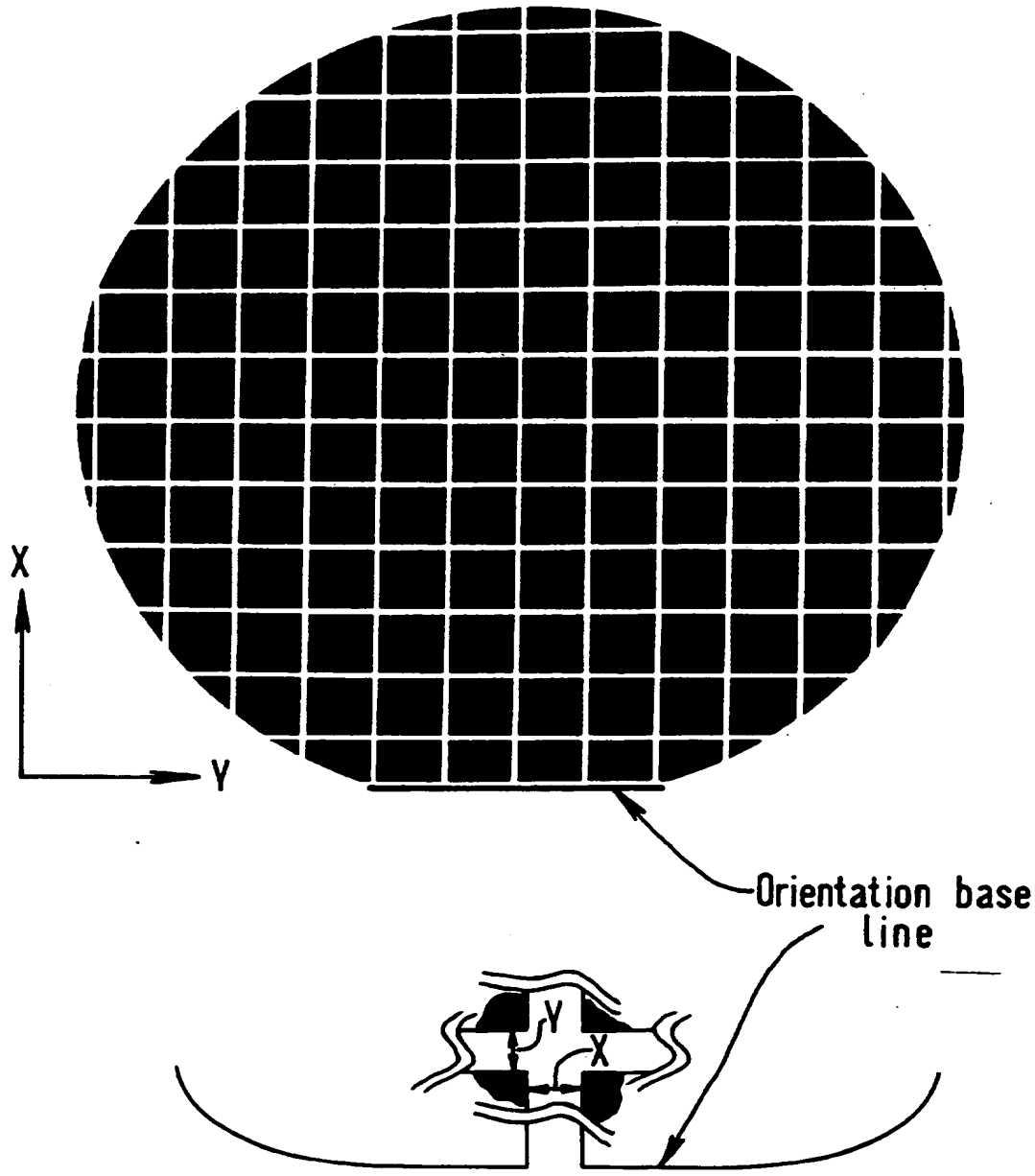


FIG. 2.

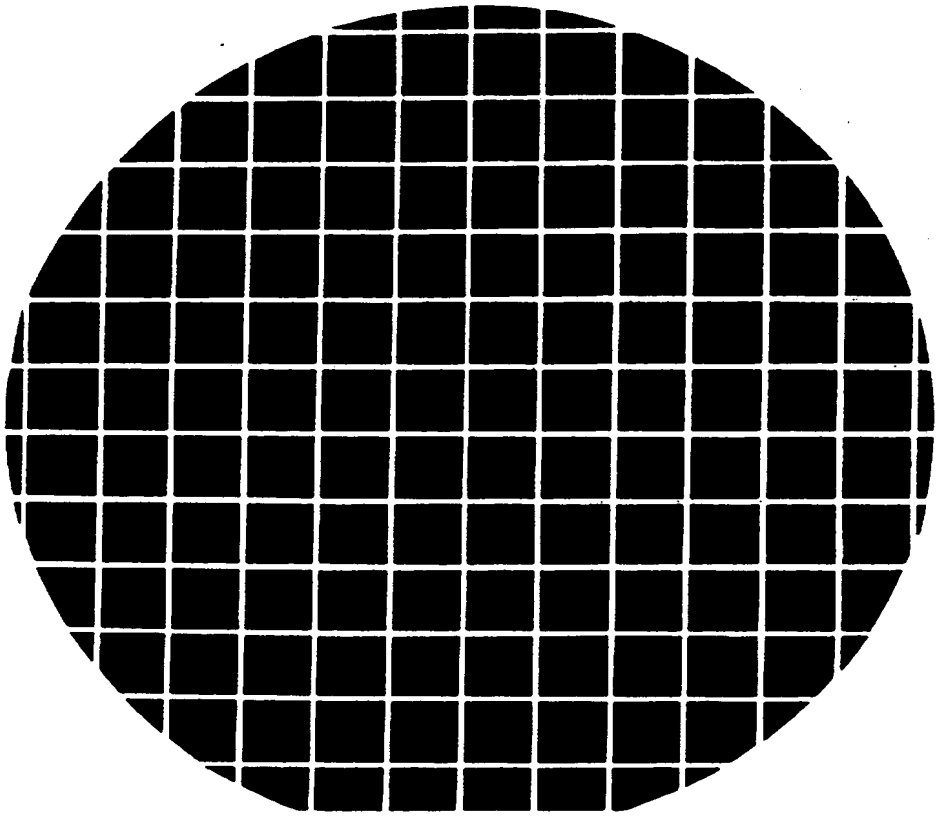
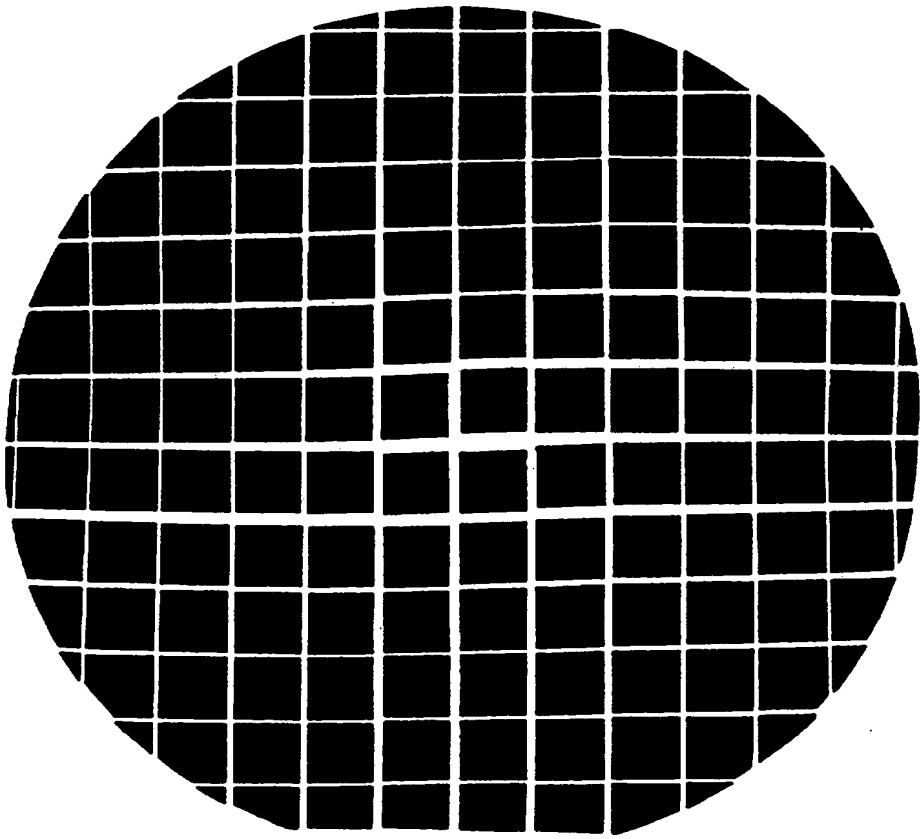


FIG. 3.



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PRESSURE SENSITIVE ADHESIVE COMPOSITION AND SHEET HAVING LAYER THEREOF

The present invention relates to a pressure sensitive adhesive composition and a pressure sensitive adhesive sheet having a layer thereof. More particularly, the present invention is concerned with a pressure sensitive adhesive sheet which exhibits satisfactory rubber elasticity and has satisfactory pressure sensitive adherence and initial adhesion to an adherend before irradiation with an energy beam but whose adhesive strength to the adherend is sharply reduced after irradiation with an energy beam without loss of rubber elasticity, so that the adherend can be removed without having the adhesive remaining thereon. The pressure sensitive adhesive sheet ensures excellent chip alignability after the cutting and separation (dicing) of a wafer into small element pieces (chips). Furthermore, the present invention is concerned with a pressure sensitive adhesive composition which can provide the above pressure sensitive adhesive sheet.

A semiconductor wafer of, for example, silicon or gallium arsenide is produced with a large diameter. This wafer is cut and separated (diced) into small element chips and is subjected to a subsequent

mounting step in which the chips are mounted on lead frames. In this process, the semiconductor wafer undergoes dicing, cleaning, drying, expanding and pickup steps in the process of being attached to a pressure sensitive adhesive sheet, and transferred to the subsequent mounting step.

Adhesive sheets which are intended for use in the processing steps of wafers, from the dicing step up to the pickup step, are required to have an adhesive force sufficient to retain the wafer and/or chips thereon during the dicing step, but in the pickup step, they are desired to only have an adhesive force of such an extent that no adhesive remains on the picked-up wafer and/or chips.

In an effort to obtain such a desired pressure sensitive adhesive sheet, Japanese Patent Laid-open Publication Nos. 60(1985)-196956 and 60(1985)-223139 proposed pressure sensitive adhesive sheets each comprising a substrate coated with a pressure sensitive adhesive comprising a low molecular weight compound having at least two photopolymerizable carbon-carbon double bonds in each molecule thereof which can be converted to a three-dimensional reticular structure by light irradiation. These proposals are based on the concept that, in a pressure sensitive adhesive tape comprising a raditation transmittable substrate and, applied thereon, a radiation curable pressure sensitive adhesive, the radiation curable compound contained in the pressure sensitive adhesive is cured by radiation irradiation so that the pressure sensitive adhesive comes to have a three-dimensional netted

structure to thereby significantly lower the fluidity thereof. However, in the pressure sensitive adhesive sheets described in the above publications, the curing reaction is likely to cause the pressure sensitive adhesive layer to suffer from a loss of rubber elasticity, so that a satisfactory extension cannot be attained in the expansion of the sheet. Therefore, the spacings between wafer chips neighboring each other are not satisfactory and not uniform thereby causing opertional error at the pickup step.

Japanese Patent Laid-open Publication No. 5(1993)-214298 teaches a pressure sensitive adhesive sheet provided with a pressure sensitive adhesive layer having, added thereto, a vinyl ether compound of relatively low molecular weight for maintaining the rubber elasticity of the adhesive layer and an unsaturated oligomer of relatively low molecular weight for rendering the adhesive layer curable by radiation irradiation. Further, Japanese Patent Laid-open Publication No. 6(1994)-49420 discloses a pressure sensitive adhesive sheet provided with a pressure sensitive adhesive layer having, added thereto, a polyfunctional urethane acrylate oligomer and a plasticizer such as a polyester compound. However, when the amount of added low molecular weight component or plasticizer is too large, this pressure sensitive adhesive suffers from a lowering of its initial adhesive strength, so that the drawback would be encountered that the low molecular weight component or plasticizer remains on the back of the semiconductor wafer chips. On the other hand, when the

amount of added low molecular weight component or plasticizer is too small, the drawback would be encountered that the reduction of the adhesive strength is unsatisfactory or the rubber elasticity cannot be obtained upon radiation irradiation. Therefore, control of the adherent properties has been very difficult before and after the radiation irradiation step.

The present invention has been made in response to the limitations of the prior art, and an object of the present invention is to provide a pressure sensitive adhesive sheet which has a satisfactory pressure sensitive adherence and initial adhesion before irradiation with an energy beam but whose adhesive strength is sharply reduced after irradiation with an energy beam while maintaining the rubber elasticity. Such a pressure sensitive adhesive sheet ensures an excellent chip alignability in the expanding step subsequent to dicing. Another object of the present invention is to provide a pressure sensitive adhesive composition which can form the above pressure sensitive adhesive sheet.

The pressure sensitive adhesive composition of the present invention comprises:

an acrylic copolymer (A),

an energy beam polymerizable urethane acrylate oligomer (B) and

an energy beam polymerizable compound having one acryloyl group or methacryloyl group in each molecule thereof (C).

It is preferred that the pressure sensitive adhesive compositions of the present invention contain a plasticizer (D).

It is also preferred that the pressure sensitive adhesive compositions of the present invention contain a crosslinking agent(E).

The pressure sensitive adhesive composition of the present invention may also contain a photopolymerization initiator (F).

The pressure sensitive adhesive sheet of the present invention comprises a substrate and, formed thereon, a pressure sensitive adhesive layer composed of the above pressure sensitive adhesive composition.

Fig. 1 is a view showing the arrangement of chips after the expansion step made with the use of the pressure sensitive adhesive sheet of Example 1;

Fig. 2 is a view showing the arrangement of chips after the expansion step made with the use of the pressure sensitive adhesive sheet of Example 2; and

Fig. 3 is a view showing the arrangement of chips after the expansion step made with the use of the pressure sensitive adhesive sheet of Comparative Example 1.

The pressure sensitive adhesive composition and pressure sensitive adhesive sheet according to the present invention will be described in detail below.

Pressure Sensitive Adhesive Composition

The pressure sensitive adhesive composition of the present invention comprises:

an acrylic copolymer (A),

an energy beam polymerizable urethane acrylate oligomer (B) and

an energy beam polymerizable compound having one acryloyl group or methacryloyl group in each molecule thereof (C).

The pressure sensitive adhesive composition of the present invention may further contain a plasticizer (D), a crosslinking agent (E) and/or a photopolymerization initiator (F) according to necessity.

Acrylic Copolymer (A)

Those acrylic copolymers commonly used in pressure sensitive adhesives can be used as the acrylic copolymer (A) in the present invention. Specifically, the acrylic copolymer (A) may be, for example, a (meth)acrylic ester homopolymer or copolymer whose main structural monomer units are formed

from the (meth)acrylic ester or a mixture of the above homopolymer and copolymer.

An alkyl (meth)acrylate having an alkyl group of 1 to 18 carbon atoms is preferably used as the (meth)acrylic ester. Besides the above monomers, a comonomer such as vinyl acetate, styrene or vinyl chloride may be used in the copolymerization for obtaining the above copolymer.

The acrylic copolymer (A) has a molecular weight of at least 200,000, preferably, from 400,000 to 2,000,000 and, still preferably, from 1,200,000 to 1,700,000. The acrylic copolymer (A) generally has a glass transition temperature of not higher than -10°C, preferably, about -70 to -20°C. The acrylic copolymer (A) exhibits adherence at room temperature (23°C).

The above acrylic copolymers may be used either individually or in combination.

Energy Beam Polymerizable Urethane Acrylate Oligomer (B)

The energy beam polymerizable urethane acrylate oligomer (B) for use in the present invention is a urethane acrylate oligomer having energy beam polymerizable double bonds. For example, it is obtained by reacting a polyol compound of the polyester or polyether type with a polyvalent isocyanate compound such as 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate or diphenylmethane-4,4'-diisocyanate to thereby obtain an isocyanate terminated urethane prepolymer and reacting the obtained

isocyanate terminated urethane prepolymer with an acrylate or methacrylate having a hydroxyl group such as 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl acrylate, 2-hydroxypropyl methacrylate, polyethylene glycol acrylate or polyethylene glycol methacrylate.

The energy beam polymerizable urethane acrylate oligomer (B) has a molecular weight of at least 500, preferably, 3000 to 30,000 and, still preferably, 5000 to 20,000. The energy beam polymerizable urethane acrylate oligomer (B) generally contains 2 to 10, preferably, 2 to 6 and, more preferably, 2 to 4 energy beam polymerizable unsaturated groups in each molecule thereof.

Energy Beam Polymerizable Compound (C)

The energy beam polymerizable compound (C) for use in the present invention is a monomer or oligomer having one acryloyl groups or methacryloyl groups in each molecule thereof. Specific examples thereof include methyl (meth)acrylate, ethyl (meth)acrylate, benzyl (meth)acrylate, cyclohexyl (meth)acrylate, butoxyethyl (meth)acrylate, N,N-dimethylaminoethyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, methoxyethylene glycol (meth)acrylate, glycidyl (meth)acrylate, isodecyl (meth)acrylate, isooctyl (meth)acrylate, lauryl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, methylol(meth)acrylamide, (meth)acrylamide, polystyrylethyl (meth)acrylate and morpholyl (meth)acrylate.

Although the proportions of added components (A), (B) and (C) in the pressure sensitive adhesive composition can arbitrarily be set, it is preferred that, in terms of the parts by weight of solid contents, the component (B) be used in an amount of, for example, 10 to 300 parts by weight, especially, 60 to 200 parts by weight and, more preferably, 90 to 150 parts by weight per 100 parts by weight of the component (A) and that the component (C) be used in an amount of, for example, 10 to 300 parts by weight, especially, 30 to 150 parts by weight and, more preferably, 60 to 120 parts by weight per 100 parts by weight of the component (A).

The adhesive strength of the above pressure sensitive adhesive composition of the present invention is sharply reduced by irradiation with an energy beam while the rubber elasticity is maintained. Suitable examples of energy beams include ultraviolet rays and electron beams. The energy beam dosage is varied depending on the type of applied energy beam. For example, when ultraviolet rays are used, the dosage thereof is preferred to range from about 40 to 200 W/cm. When electron beams are used, the dosage thereof is preferred to range from about 10 to 1000 krad. This energy beam irradiation produces a marked reduction in the adhesive strength of the composition of the present invention. For example, whereas the adhesive strength to the specular surface of a semiconductor wafer ranges from about 100 to 2000 g/25 mm before the energy beam irradiation, control can be effected so that the

adhesive strength after the energy beam irradiation is about 1 to 50% of that before the energy beam irradiation.

On the other hand, the elasticity of the composition ranges from about 10^5 to 10^6 dyne/cm^2 before the energy beam irradiation and ranges from about 10^6 to 10^8 dyne/cm^2 after the energy beam irradiation. Thus, the rubber elasticity of the composition is maintained after the energy beam irradiation.

Plasticizer (D)

In the present invention, it is preferred that the plasticizer (D) be added to the components (A), (B) and (C). This plasticizer is a compound which does not contain any photopolymerizable unsaturated bonds in its molecule and which lowers the elasticity of the cured adhesive composition. Examples of suitable plasticizers include:

phthalic ester plasticizers such as dimethyl phthalate, diethyl phthalate, di-2-ethylhexyl phthalate, di-n-octyl phthalate and dinonyl phthalate;

dibasic fatty acid ester plasticizers such as diisodecyl succinate, dioctyl adipate and dioctyl sebacate;

glycol ester plasticizers such as diethylene glycol dibenzoate and dipentaerythritol hexaesters;

polyether-ester plasticizers such as polyethylene glycol di-2-ethylhexoate and polyethylene glycol di-2-stearate;

fatty acid ester plasticizers such as butyl oleate and methyl acetylricinolate;

phosphoric ester plasticizers such as trioctyl phosphate and triphenyl phosphate;

epoxidized plasticizers such as epoxidized soybean oil, epoxidized linseed oil and butyl epoxystearate;

polyester plasticizers such as polypropylene adipate and polypropylene sebacate; and

other plasticizers such as trioctyl trimellitate and tetraoctyl pyromellitate.

Of these plasticizers, the polyether-ester plasticizers are preferred.

It is preferred that each of the above plasticizers (D) be used in an amount of 1 to 150 parts by weight, especially, 5 to 50 parts by weight per 100 parts by weight of the component (A).

Crosslinking Agent (E)

Further, a crosslinking agent (E) can be added to the pressure sensitive adhesive composition of the present invention according if required. Examples of suitable crosslinking agents include:

polyvalent polyisocyanate compounds and trimers thereof;

isocyanate terminated urethane prepolymers obtained by reacting the above polyisocyanate compounds with polyol compounds; and

blocked polyisocyanate compounds obtained by terminating the above polyisocyanate compounds, polyisocyanate compound trimers and isocyanate terminated urethane prepolymers with phenol, oximes or the like.

Specific examples of suitable polyvalent isocyanate compounds include 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate, diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'-diisocyanate, 3-methyldiphenylmethane diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, dicyclohexylmethane-4,4'-diisocyanate, dicyclohexylmethane-2,4'-diisocyanate and lysine isocyanate.

It is preferred that each of the above crosslinking agents (E) be added in an amount of 0.1 to 10 parts by weight, especially, 1 to 10 parts by weight per 100 parts by weight of the component (A).

Photopolymerization initiator (F)

When ultraviolet rays are employed as the energy beam, the polymerization/curing time and the ultraviolet ray dosage can be reduced by mixing a photopolymerization initiator (F) in the above composition of the present invention.

Specific examples of suitable photopolymerization initiators (F) include benzophenone, acetophenone, benzoin, benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether, benzoin isobutyl ether, benzoin benzoic acid, methyl benzoin benzoate, benzoin dimethyl ketal, 2,4-diethylthioxanthone, 1-hydroxycyclohexyl phenyl ketone, benzyl diphenyl sulfide, tetramethylthiuram monosulfide, azobisisobutyronitrile, benzil, dibenzyl, diacetyl and β-chloroanthraquinone. It is preferred that the

photopolymerization initiator (F) be used in an amount ranging from 0.1 to 20 parts by weight, especially, from 2 to 10 parts by weight per 100 parts by weight of the sum of the components (B) and (C).

The pressure sensitive adhesive composition of the present invention can be obtained by blending together the above acrylic copolymer (A), energy beam polymerizable urethane acrylate oligomer (B) and energy beam polymerizable compound (C), preferably, optionally along with the plasticizer (D), the optionally added crosslinking agent (E) and the optional photopolymerization initiator (F) according to the conventional technique.

The pressure sensitive adhesive composition of the present invention exhibits satisfactory rubber elasticity and has satisfactory pressure sensitive adherence and initial adhesion to an adherend before irradiation with an energy beam. Upon the energy beam irradiation, however, the adhesive strength to the adherend is sharply reduced while maintaining the rubber elasticity, so that the adhesive composition can be removed from the adherend without residue remaining on the adherend.

Therefore, the pressure sensitive adhesive composition of the present invention is suitable for use in applications in which peeling is effected after sticking.

Pressure Sensitive Adhesive Sheet

The pressure sensitive adhesive sheet of the present invention comprises a substrate and, formed thereon, a pressure sensitive adhesive layer of the above pressure

sensitive adhesive composition. The pressure sensitive adhesive sheet of the present invention can be obtained by coating a variable substrate with an appropriate thickness of the above pressure sensitive adhesive composition according to the conventional technique employing a comma coater, gravure coater, die coater, reverse coater or the like and drying the composition to thereby form a pressure sensitive adhesive layer on the substrate. When considered necessary, a release sheet is applied onto the pressure sensitive adhesive layer.

Although varied depending on the use, the thickness of the pressure sensitive adhesive layer generally ranges from about 1 to 100 μm, preferably, from about 5 to 50 μm and, more preferably, from about 10 to 30 μm.

On the other hand, the thickness of the substrate generally ranges from about 10 to 300 μm, preferably, from about 20 to 200 μm and, more preferably, from about 50 to 150 μm.

The configuration of the pressure sensitive adhesive sheet of the present invention is not limited and the sheet may have the form of, for example, a tape or a label.

It is preferred that a synthetic resin film which is extendable in not only the direction of the length but also the direction of the width be used as the substrate.

When the pressure sensitive adhesive sheet of the present invention having been stuck to an adherend is irradiated with an energy beam, the adhesive strength thereof is sharply reduced. Thus, this sheet can be removed from

the adherend without causing any adhesive residue to remain on the adherend.

Therefore, the pressure sensitive adhesive sheet of the present invention is very suitable for use in applications in which peeling is effected after sticking. For example, it is used as a semiconductor processing or surface protective pressure sensitive adhesive sheet.

The surface protective pressure sensitive adhesive sheet is stuck onto the surface of, for example, a decorative laminate, a glass plate, a metal plate or a plastic plate and protects the same from soiling or scratching during transit or processing. When the protection is no longer needed, the surface protective pressure sensitive adhesive sheet can easily be peeled off by irradiating it with an energy beam.

The semiconductor processing pressure sensitive adhesive sheet is employed at the time of, for example, polishing the back of a wafer or wafer dicing.

A multiplicity of circuits are formed on a surface of a semiconductor wafer, and semiconductor chips are produced by conducting cutting and separation (dicing) of the semiconductor wafer for each individual circuit. If the thickness of the wafer is irregular or an oxide layer has been formed on the back of the wafer, the chips obtained suffer from irregularities in performance. Thus, the back of the wafer is polished after the completion of the wafer processing. However, the circuits can be damaged by polishing debris. In this instance, the

sticking of the pressure sensitive adhesive sheet of the present invention to a frontal face of the wafer enables the prevention of damage to the circuits. Moreover, the pressure sensitive adhesive sheet can easily be peeled off by irradiating it with an energy beam without causing adhesive residue to remain on the wafer, so that the wafer is not soiled.

Likewise, the the circuits may be damaged by cutting debris during wafer dicing. In this instance as well, the circuits can be protected by the pressure sensitive adhesive sheet of the present invention. Further, the pressure sensitive adhesive sheet of the present invention can be stuck onto the back of the wafer for fixing the wafer so that the wafer is stably held at the time of dicing. This pressure sensitive adhesive sheet of the present invention can hold the wafer with a satisfactory adhesive strength before irradiation with an energy beam and has a sharp reduction in the adhesive strength upon irradiation with an energy beam after the dicing, so that the semiconductor chips can easily be picked up without suffering from soiling by the adhesive. Further, the adhesive layer maintains the rubber elasticity even after energy beam irradiation, so that the entire sheet undergoes a satisfactorily uniform extension in the expanding step. Accordingly, the spacings between chips neighboring each other are satisfactorily large to thereby further facilitate chip pickup operation.

The substrate for use in the pressure sensitive adhesive sheet of the present invention is not particularly limited. However, when ultraviolet rays are used as the energy beam, it is, for example, selected from among transparent films such as polyethylene, polypropylene, polybutene, polybutadiene, polymethylpentene, polyvinyl chloride, vinyl chloride copolymer, polyethylene terephthalate, polybutylene terephthalate, polyurethane, ethylene/vinyl acetate copolymer, ionomer resin, ethylene/(meth)acrylic acid copolymer, ethylene/(meth)acrylic acid ester copolymer, polystyrene and polycarbonate films which may be noncrosslinked or crosslinked and laminates thereof.

When electron beams are used as the energy beam, it is not necessary for the substrate to be transparent. Thus, each of not only the aforementioned transparent films but also opaque films obtained by coloring them and fluororesin films can be used as the substrate.

Moreover, the above pressure sensitive adhesive layer can contain compounds disclosed in Japanese Patent Laid-open Publication No. 62(1987)-153377 which take on color upon energy beam irradiation or can contain powdery energy beam scattering inorganic compounds disclosed in Japanese Patent Laid-open Publication No. 62(1987)-153375.

Furthermore, an antistatic agent can be added to the above pressure sensitive adhesive layer. The addition of the antistatic agent suppresses the generation of static electricity at the expanding or pickup step, so that the

chip reliability is enhanced. Examples of suitable antistatic agents include generally known surface activators such as anionic, cationic, nonionic and amphoteric activators and powdery materials such as powdery carbon black, silver, nickel, antimony doped tin oxide and tin doped indium oxide. It is preferred that the antistatic agent be used in an amount ranging from 0 to 50% by weight, especially, from 0 to 30% by weight in the pressure sensitive adhesive layer.

In the present invention, the substrate may have abrasive grains dispersed therein as disclosed in Japanese Patent Laid-open Publication Nos. 63(1988)-205382 and 63(1988)-205383.

The pressure sensitive adhesive sheet of the present invention has a sharp reduction of the adhesive strength upon irradiation with an energy beam, so that the wafer chips can easily be picked up from the adhesive sheet. Further, the adhesive layer maintains a significant rubber elasticity even after energy beam irradiation, so that desired chip spacings can easily be obtained at the expanding step and no chip dislocation occurs, thereby ensuring a stable chip pickup operation.

As is apparent from the foregoing, the pressure sensitive adhesive composition of the present invention exhibits satisfactory rubber elasticity and has satisfactory pressure sensitive adherence and initial adhesion to an

adherend before irradiation with an energy beam. Upon energy beam irradiation, however, the adhesive strength to the adherend is sharply reduced while maintaining the rubber elasticity, so that the adhesive composition can be removed from the adherend without residue remaining on the adherend. Further, this pressure sensitive adhesive composition ensures excellent chip alignability in the expanding step subsequent to energy beam irradiation. Therefore, the pressure sensitive adhesive composition of the present invention is suitable for use in applications in which peeling is effected after sticking, for example, it can be advantageously used in wafer processing or a surface protective pressure sensitive adhesive sheet.

The present invention will further be illustrated below with reference to the following Examples which in no way limit the scope of the invention.

In the following Examples and Comparative Example, the "180° peeling adhesive strength" and "chip alignability" were evaluated in the following manners.

<u>180° peeling adhesive strength</u>

The pressure sensitive adhesive sheet obtained in each of the following Examples and Comparative Example was stuck onto a specular face of a semiconductor wafer at 23°C in a 65% RH (relative humidity) atmosphere by reciprocating a 2 kg rubber roller thereon, allowed to stand still for 30 min and peeled by means of a universal tensile tester (TENSILON/UTM-4-100 manufactured by Orientec Corporation) at a peeling speed of 300 mm/min to thereby determine a 180° peeling adhesive

strength. Also, the pressure sensitive adhesive sheet was stuck and allowed to stand still under the same conditions, and was irradiated from the substrate sheet side at a line speed of 5 m/min with ultraviolet rays emitted from a high pressure mercury lamp (220 mW/cm^2) disposed at a distance of 10 cm from the sheet. Thereafter, the 180° peeling adhesive strength was measured in the same manner.

Chip alignability

The pressure sensitive adhesive sheet was stuck onto a 6-inch silicon wafer and fixed by means of a ring frame, and diced into 12 mm square chips with a dicer (manufactured by DISCO Corporation). A 27HECC 2050 blade (manufactured by DISCO Corporation) was used to cut into the sheet to a depth of μm in the dicing operation. After the dicing, the specimen was irradiated with ultraviolet rays (220 mW/cm^2, 160 J/cm^2) from the back of the sheet, and the sheet was expanded by 17 mm with the use of an expanding jig (CPS-100AS expanding unit manufactured by Nichiden Machinery Ltd.). At that time, the chip alignability was evaluated by visual inspection and by the measurement of chip spacings.

All the chip spacings were measured with respect to an arbitrary row of chips passing around the center of the silicon wafer. The distance between neighbouring chips (X) was measured along the Y-axis (i.e. the gap between chip sides perpendicular to the orientation base line), and (Y) along the X-axis (i.e. the gap between chip sides parallel to the orientation base line), as shown in Figure 1. The average (x) of the measurements was calculated as an indication of chip

spacing and the standard deviation (σ_{n-1}) thereof was calculated as an indication of chip alignability. The smaller the standard deviation, the smaller the chip spacing irregularity and the better the chip alignability to thereby avoid opertional error at the pickup stage.

The following acrylic copolymer (A), energy beam polymerizable urethane acrylate oligomer (B), energy beam polymerizable compound (C), plasticizer (D), crosslinking agent (E) and photopolymerization initiator (F) were employed in the Examples.

Acrylic copolymer (A)

(A) : copolymer of butyl acrylate and 2-hydroxyethyl acrylate having a weight average molecular weight of 15 x 10^5;

Energy beam polymerizable urethane acrylate oligomer (B):

(B) having a weight average molecular weight of 10,000 and three acryloyl functional groups;

Energy beam polymerizable compound (C)

(C) : tetrahydrofurfuryl acrylate having a weight average molecular weight of 270 and one acryloyl functional group;

Plasticizer (D)

(D) : ether ester plasticizer having a weight average molecular weight of 500 e.g. polyethyleneglycol-di-2-ethylhexoate containing between 4 and 5 ethyleneoxide units.

Crosslinking agent (E)

(E) : polyisocyanate crosslinking agent e.g. trimethylolpropane-tri-(N-2-isocyanate-toluyl)carbamate; and

Photopolymerization initiator (F)

(F) : benzophenone type photopolymerization initiator e.g. 1-hydroxy-cyclohexyl-phenylketone.

Example 1

100 parts by weight of component A, 120 parts by weight of component B, 80 parts by weight of component C, 3.5 parts by weight of component E and 9 parts by weight of component F were blended together, thereby obtaining a pressure sensitive adhesive composition.

An 80 μm thick polyvinyl chloride film was coated with the above pressure sensitive adhesive composition so that the coating thickness after drying would be 10 μm and dried at 100°C for 1 min. Thus, a pressure sensitive adhesive sheet was obtained.

The "180° peeling adhesive strength" and "chip alignability" of the obtained pressure sensitive adhesive sheet were evaluated in the above manners. The results are given in Table 1. Fig. 1 is a view showing the arrangement of chips after the expansion step made with the use of the said pressure sensitive adhesive sheet.

Example 2

The same procedure as in Example 1 was repeated except that 15 parts by weight of component D was added to the composition. The results are given in Table 1.

Fig. 2 is a view showing the arrangement of chips after the expansion step made with the use of the said pressure sensitive adhesive sheet.

Comparative Example 1

Without the use of component C, 100 parts by weight of component A, 120 parts by weight of component B, 3.5 parts by weight of component E and 5.5 parts by weight of

component F were blended together, thereby obtaining a pressure sensitive adhesive composition.

The same procedure as in Example 1 was repeated for said pressure sensitive adhesive composition. The results are given in Table 1. Fig. 3 is a view showing the arrangement of chips realized at the expansion made with the use of the obtained pressure sensitive adhesive sheet.

As is apparent from the results in Table I, in Examples 1 and 2, not only was the adhesive strength sharply reduced after irradiation with ultraviolet rays but satisfactory chip spacings were also obtained after expansion of the pressure sensitive adhesive sheet, with excellent chip alignability, as shown in Figs. 1 and 2.

By contrast, in Comparative Example 1, chip spacings were nonuniform at the expansion of the pressure sensitive adhesive sheet and although the adhesive strength was reduced upon ultraviolet ray irradiation, operational error would be caused at the time of pickup, as shown in Table 1 and Fig. 3.

Table 1

	Pressure sensitive adhesive composition (parts by weight)						Adhesive strength (g/25 mm)		Arrangement of chip	Chip spacing, alignability (μm) X		Y	
	A	B	C	D	E	F	Before irradiation	After irradiation		x	σ_{n-1}	x	σ_{n-1}
Ex.1	100	120	80	0	3.5	9	170	55	good	490	60	455	55
Ex.2	100	120	80	15	3.5	9	150	50	good	535	50	535	40
Comp Ex.1	100	120	0	0	3.5	5.5	390	60	poor	495	300	445	190

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Claims:

1. A pressure sensitive adhesive composition comprising:
an acrylic copolymer (A),
an energy beam polymerizable urethane acrylate oligomer (B) and
an energy beam polymerizable compound having one acryloyl group or methacryloyl group in each molecule thereof (C).

2. A pressure sensitive adhesive composition as claimed in claim 1, which further comprises a plasticizer (D).

3. A pressure sensitive adhesive composition as claimed in claim 1 or claim 2, which further comprises a crosslinking agent (E).

4. A pressure sensitive adhesive composition as claimed in any of claims 1 to 3, which further comprises a photopolymerization initiator (F).

5. A pressure sensitive adhesive sheet comprising a substrate and, formed thereon, a pressure sensitive adhesive layer composed of a pressure sensitive adhesive composition as claimed in one of claims 1 to 4.

6. A process for producing a pressure sensitive adhesive composition as claimed in claim 1 comprising blending:
an acrylic copolymer (A),
an energy beam polymerizable urethane acrylate oligomer (B) and
an energy beam polymerizable compound having one

acryloyl group or methacryloyl group in each molecule thereof (C).

7. A process as claimed in claim 6, which further comprises blending a plasticizer (D).

8. A process as claimed in claim 6 or claim 7 which further comprises blending a crosslinking agent (E).

9. A process as claimed in any one of claims 6, 7 or 8 which further comprises blending a photopolymerization initiator (F).

10. The use of a pressure sensitive adhesive sheet as claimed in claim 5 as a protective coating.

11. The use of a pressure sensitive adhesive sheet as claimed in claim 5 in semiconductor processing.

12. A pressure sensitive adhesive composition substantially as herein described with reference to the Examples.

13. A process for manufacturing a pressure sensitive adhesive composition substantially as herein described with reference to the Examples.

14. A pressure sensitive adhesive composition manufactured by a process as claimed in claims 6 to 9.

The Patent Office

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Application No:	GB 9708263.0	**Examiner:**	K. Macdonald
Claims searched:	1-14	**Date of search:**	19 June 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): C3V(VAM,VBC)

Int Cl (Ed.6): C09J

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2221470 A	(FSK) see Claim 1; page 10, line 32-page 11, line 9; page 14, lines 13-26	1 at least
X	GB 2216136 A	(KENDELL) see Claim 1; page 4, line 13-page 5, line 13	1 at least
X	GB 1599281	(ICI) see Example 1	1 at least
X	EP 0311288 A2	(WESTINGHOUSE) see Claim 1	1 at least
X	WPI Abstract Accession No.83-823346/198347 & JP 580174475 A (MITSUBISHI) 13.10.83 (see abstract)		1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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